

Measuring Time, Distance, and Mass in the Arad Fortress, Early 6th Century BCE

Amir Gorzalczany^a and Baruch Rosen^b

^a The Israel Antiquities Authority, amir@israntique.org.il

^b Independent Researcher

Abstract

While Biblical Hebrew literacy has been widely studied, numeracy—the cognitive ability to understand and manipulate numbers—remains a largely overlooked, underexplored domain. This article addresses this gap by examining the Arad Ostraca. These texts were produced in the early 6th century BCE and concern routine administrative operations, including issuing, receiving, and recording goods such as wine, bread, and grain. We pay close attention to timekeeping systems, including references to days, months, and a single regnal year and propose that some documents reflect a structured six-day supply cycle. It divides a 30-day month into five segments, establishing a calendrical system, which might have been influenced by Egyptian or Mesopotamian administrative traditions. Furthermore, the use of hieratic numerals in these otherwise Hebrew texts suggests a complex hybrid scribal culture. The paper argues that scribes and officials at Arad regularly engaged in quantification and planning, embedding numeracy into the syntax and lexicon of their written communications. However, because these inscriptions stem from a military and bureaucratic context, they likely represent a specialized linguistic register and do not necessarily testify to how Biblical Hebrew was used in other circles. The study thus contributes to our understanding of cognitive, logistic, and linguistic development in Iron Age Judah, while cautioning against generalizations beyond the administrative sphere.

Keywords: dating; accounting; military rations; Arad Ostraca; numeracy; month division

Amir Gorzalczany and Baruch Rosen. 2025. Measuring Time, Distance, and Mass in the Arad Fortress, Early 6th Century BCE.

Jerusalem Journal of Archaeology 8: 106–119.

ISSN: 2788-8819; <https://doi.org/10.52486/01.00008.6>; <https://jjar.huji.ac.il>



1. Introduction

Scholars of human cognition consider literacy and numeracy to be tightly intertwined abilities. *Literacy* is the ability to write, read, understand, record, and effectively communicate written information. *Numeracy* is the ability to comprehend spoken and written numbers and associated symbols and to manipulate them in a purposeful, orderly, and coherent manner. The concept of numeracy is especially applicable to the three aspects of material reality: distance, time, and mass (or weight). It has also been suggested that, in the course of human cognitive evolution, numeracy preceded literacy (Robson 2007; Chrisomalis 2009: 59 and *passim*; Grotlüschen, Desjardins, and Liu 2020).

Notwithstanding their closely intertwined relationship, ongoing studies of Biblical Hebrew (BH) have yielded important insights about issues of literacy (Rollston 2010; Mandell 2023 and references therein), but practically very little about numeracy. In this article, we argue that this understudied area warrants closer scholarly attention to how goods were counted and how time and distance were measured.

2. The Arad Ostraca

The Arad excavations, which ended in 1967 (Aharoni 1981: 3), produced approximately one hundred Biblical Hebrew inscriptions dating from the late Iron Age. The site has been extensively studied, underscoring its sociological, historical, and political significance. It was a Judahite fortress that guarded the southern approaches to the Kingdom of Judah and was destroyed around 586 BCE, at the end of the First Temple period (Herzog et al. 1984; Mazar and Netzer 1986; Herzog 1987; 2002). Unlike other known Biblical Hebrew corpora, the Arad Ostraca feature numerous cases of applied numeracy (e.g., Lemaire 1977: 155–184; Pardee 1978; 1982; Aharoni 1981; Renz and Röllig 1995; Dobbs-Allsopp et al. 2005: 8–108; Na’aman 2011; 2022; Ahituv 2012: 110–112; Rosen and Gorzalczy 2024; Vainstub 2024). Below, we analyze several notable documents and draw on them to assess the presence and character of active numeracy.

While the Arad Ostraca pave the way to significant insights into late Iron Age Judahite Biblical Hebrew, linguistic caution is warranted. These texts likely reflect a distinct variant of Biblical Hebrew associated with military logistics and bureaucratic operations, which is unlike the language of prophets, poets, or the royal court (Palchevska et al. 2023). Comparable to modern military

registers, the Arad Ostraca are characterized by a concise command-oriented language (e.g., AO 24:18–19; Aharoni 1981: 46–49). For example,

1. **AOs 1, 2, and 16** feature postscripts that differ in tone from the main texts. While the primary content is directive and specific, the postscripts have a more “wine-talk” style—imprecise in time, location, and quantity—possibly reflecting informal epistolary exchanges among officers (Rosen and Gorzalczy 2024: 38–39).
2. **AO 16 verso** contains the rare Hebrew root *צַעַה/הֲצַעַע* associated with wine container measurements. Once linked to the royal wine industry, it survives only in metaphorical biblical usage, likely due to the destruction of the Judahite royal bureaucracy. Elsewhere, we pointed out the use of technical wine talk as an internal jargon of military storekeepers (Rosen and Gorzalczy 2024).
3. **AO 2** features the root *סַבַּב/סֹבַב*, which also appears in Lachish Letter 4, and suggests the postponement of specific military routines (e.g., patrols or inspections; Ahituv 1987: 114; 2012: 73, 91). Its recurrence hints at an army slang shared between Lachish and Arad, though the boundary between military and civilian usage remains unclear (Kletter 2020: 149–159).

For our present concerns, it is notable that the Arad Ostraca attest to a developed numeracy applied by soldiers, clerks, or other officials for issuing, receiving, storing, manipulating, and distributing various goods, primarily victuals, such as wheat and bread. For example, AO 3 records the routine management of wheat warehouses and bread production by a military or administrative facility (Aharoni 1981: 17). It says, “To Eliashib, and now! Issue from the wine three baths. And Ḥananyahu has commanded you to Beer-Sheba with two donkeys’ load, and you shall wrap up the dough. And count the wheat and the bread, and take....”

This text illustrates the use of descriptive and numerical devices for quantification:

- **Volume** is specified (three baths of wine).
- **Transport capacity** is quantified (two donkey loads).
- **Distance** is indicated via directional reference (Arad to Beer-Sheba).
- **The order to count** wheat and bread reflects the operational significance of numeracy.

While the precise meaning of *bath* remains debated, scholars generally agree that it constitutes a type of numerical data. Some interpret it as a standardized container (Lipschits et al. 2010), while others argue it denotes an abstract unit of volume used with non-standardized containers (Kletter 2009; 2014). Either way, numeracy is essential, whether for summing or multiplying measured units. Similarly, *donkey load* functions as a traditional unit of weight, still in use in some contemporary societies (Jones 2001; Hanekom 2004). The transport of mixed cargo requires preparatory calculations to prevent overloading (Kletter 1998: 71–72). Although the dough's weight is not specified, the text notes that it was wrapped for transport, implying logistical planning.

Regular tracking of wheat-to-bread ratios would have enabled the detection of discrepancies, whether accidental or deliberate, and helped establish production standards. This reflects Egyptian accounting methods (Gillings 1972: 128), and Egyptian military numeracy provides useful parallels that are likely to have influenced Judahite practices. This hypothesis is supported by AO 34, which describes sizeable quantities of cereals (wheat and barley, likely stored in silos) recorded with hieratic numerals, a non-Hebrew script employed for precise numerical notation (Kletter 1998; Vainstub 2024). These hieratic numerals were also used by Egyptian military scribes (Ahituv 2012: 203–208; Na'aman 2020).

Recent developments in the study of Iron Age inscriptions further contextualize the Arad material. Around 2020, a team from Tel Aviv University began a technological re-examination of the Arad Ostraca, yielding new data that refine our understanding of Biblical Hebrew in the late Iron Age (e.g., Faigenbaum-Golovin et al. 2021). Meanwhile, additional Iron Age sites have produced new ostraca bearing Hebrew script, contributing valuable insights into the vocabulary, grammar, and linguistic development of the period (Faigenbaum-Golovin et al. 2016; 2017; 2021; Garfinkel and Mendel-Geberovich 2020; Mandell 2023). While these findings lie beyond the focus of the present study, they underscore the broader significance of the Arad corpus within the evolving landscape of Biblical Hebrew research.

3. Time Measurement and Use in the Arad Fortress

3.1. Year

The Arad Ostraca refer to regnal years only once, in Ostrakon AO 20. It is inscribed on a pithos and indicates the third year of an unnamed king's reign

(Lemaire 1977: 184–186; Aharoni 1981: 40–41; Aḥituv 2012: 118). Aharoni (1981: 40–41) argued that a month is also indicated, aligning it with biblical date formulae. However, this reading has not been widely accepted.

3.2. Month

The term *month* appears six or seven times in the Arad Ostraca. For example, in AO 5:13, the lexeme *hōdeš* is linked to a transaction, possibly involving a royal tax or religious tithe. Significantly, however, in Biblical Hebrew, it can denote either the day of the new moon or the entire lunar month (*Encyclopaedia Biblica* s.v. “חֹדֶשׁ”; Markowitz, Carswell Smart, and Toynbee 2024), and it is often unclear which is the case.

3.3. Day

The lexeme *day* appears nine times in the Arad Ostraca. It is spelled *ym* (יַם) also in the Siloam Inscription and in the Lachish Letters (Torczyner 1940: 30, 139–140, 148–153; Aḥituv 1987: 235; 2012: 58). It is unlike standard Biblical Hebrew, which typically employs the full three-letter form *ywm* (יוֹם) (Aḥituv 2012: 4). The Hebrew term denotes two natural cycles: (1) sunrise to sunset and (2) sunset to the following sunset (*Encyclopaedia Biblica* s.v. “יוֹם”).

The term is used in several ways. Relatively straightforward citations are observed in AOs 1:4, 7:6, 17b verso, and 32. In AOs 2, 7, and 8, *day* is used as a unit of ration allocation (Aharoni 1981: 15, 22–23). In AO 24:19, it is used rhetorically to convey urgency in response to a royal command (Aḥituv 2012: 125), highlighting its function as both a temporal marker and a tool of administrative emphasis. On one occasion, the phrase *day's end* is employed (AO 40:11–12); it is spelled רַדִּים (evening?), a form transliterated by Aharoni as two lexemes יַם רַד (“the day went down”; Aharoni 1981: 71; Aḥituv 2012: 137). Similar expressions in Judges describe the end of the day using synonymous lexemes: *natah* (“bent,” Judg 19:8), *rafah* (“weakened,” Judg 19:9), and *yarad* (“went down,” Judg 19:11), the last being identical to the term in AO 40. The form רַדִּים may reflect colloquial or spoken usage.

Also notable in this context is the time marker *maḥar* (“tomorrow”), which appears in AO 2:6. While in late Biblical Hebrew, *maḥar* can imply procrastination (e.g., Prov 3:28), in Arad, it is paired with the warning “do not be late,” emphasizing the strict scheduling demands of the supply system.

Table 1. Time-related expressions (years, months, days) in the Arad Ostraca.

Text	Page in Aharoni (1981)	AO
“...and write the name of the day...”	12	1:4
“...for the four days... tomorrow”	15	2:6
“...before the month passes...”	20	5:13
“...in the th[ird] ...”	21	6
“...for the tenth of the month... until the sixth of the month... and write on the second...”	22	7:6
“...from the thirteenth... until the eighteenth...”	23	8
“...on the twenty-fourth of the month Nahum gave oil...”	32	17b verso
“...on the third of the month of sah[...]”	40	20
“...this very day...”	46	24:19
“...on the eighth of the month...”	60	32
“...day down (sunset)”	70	40:11–12

4. The Division of the Month into “Weeks”

The timekeeping practices featured in the Arad Ostraca align in most respects with established time-management systems known from the broader Biblical Hebrew corpus. However, as suggested by Dobbs-Allsopp et al. (2005: 12–15), AOs 7 and 8 may preserve traces of a lesser-known calendrical order: the division of a 30-day month into five equal six-day spans (Table 1). AO 7 documents the issuance of wine (and possibly oil) on Day 1 and its designation for consumption over a six-day period with instructions to record the transaction on the second day. Although fragmentary, AO 8 similarly records an allocation over a six-day span and may include a reference to an additional, related activity. “In such a case, the month divisions would be days 1–6 (as in AO 7:3–5), 7–12, 13–18 (as in AO 8:2–4), 19–24...” (Dobbs-Allsopp et al. 2005: 13).

A 1933 manual of the British Royal Army Service Corps offers an interesting parallel, despite being authored millennia later. It suggests that the logistical systems of Arad and the British Army shared similar characteristics. Both employed fixed intervals—six-day spans at Arad and scheduled “issue days” in the British Army—to organize provisioning, prevent loss, and optimize human resource allocation. Food spoils after several days. Thus, the six-day span and the “issue days” feature a compromise between minimizing handling time

and assuring food freshness. Both reflect a consistent military logic: ensuring that food and equipment reach personnel reliably and in a timely manner. As the British manual states, “It will usually be found convenient to issue bread and meat daily, groceries weekly, and forage weekly or twice weekly, on specified days” (*Royal Army Service Corps Training*: 229–231). The Arad texts thus preserve not only early evidence of numeracy and bureaucratic literacy but also a form of logistical reasoning that remains recognizable in modern military operations.

If a seven-day week existed in Arad, it was possibly replaced by a six-day cycle, which divided the 30-day month into five segments, facilitating foodstuffs calculations (Table 2). The designated “issue days” likely corresponded to Days 1, 7, 13, 19, and 25. Such a calendrical system would have enabled both storekeepers (e.g., Eliashib) and recipients (e.g., the *Kittiyim*) to plan and manage provisions more effectively by distinguishing, for example, between perishable and durable foodstuffs. Restricting storeroom access to specific days would have improved oversight, minimized spoilage and theft, and reduced the need for continuous labor. Nonetheless, emergency distributions appear to have been permitted, as evidenced by AOs 3, 17b, and 32.

This arrangement implies an administrative year composed of twelve 30-day months, totaling 360 days (see below). While it remains possible that the six-day groupings cited in AOs 7 and 8 are coincidental, their occurrence in a highly structured and efficient supply system supports the hypothesis of a deliberately planned calendar. This interpretation aligns with Aharoni’s proposal that “Once a month, there was an inventory made by the royal scribe, and the authorizations were preserved up to this examination” (Aharoni 1981: 144). A similar recommendation appears in the British military manual: “As soon as possible after the end of each month, the completed account, together with all supporting vouchers, is forwarded to the local auditor of the command (or, where there is no local auditor, to the War Office)” (*Royal Army Service Corps Training*: 231). The records in AOs 7 and 8 may be remnants of such a system.

Table 2. Proposed six-day supply cycles in Arad (bold digits mark days mentioned in the ostraca).

Fifth of the month	Day	Day	Day	Day	Day	Day	Reference
1	1	2	3	4	5	6	AO 7
2	7	8	9	10	11	12	AOs 7, 32
3	13	14	15	16	17	18	AO 8
4	19	20	21	22	23	24	AO 17b
5	25	26	27	28	29	30	

5. Thirty-day Months in Late Iron Age Judah

Ancient Mesopotamian societies extensively used a schematic 360-day year, which functioned alongside the lunar calendar (Englund 1988; Ben-Dov 2021). A comparable system also operated in Pharaonic Egypt (Canhão 2013), including the division of months into three 10-day periods, the so-called “civilian month” (Porceddu et al. 2008). Additional Egyptian temporal orders comprise two, three, and fifteen-day-long spans (Vymazalová 2016).

Ben-Dov (2021) has posited that a similar 360-day administrative calendar may have been in use in late Iron Age Judah. He based his hypothesis on nine Iron Age II perforated plaques, most of which bear three rows of ten holes each, which he designated *calendar plaques* (Fig. 1). Drawing on biblical textual parallels, he argued that these reflect a year composed of twelve 30-day months.

Additional plaques, likely from the same region and period, exhibit different configurations. For example, one plaque from the City of David has fifteen holes (Fig. 2), whereas another from ‘Aroer features forty-two (Fig. 3). These variations suggest that not all plaques necessarily served calendrical functions, and some may have been used for tallying or other administrative purposes (e.g., Grandell 1977; Baxter 1989). Thus, the label *calendar plaque* may be somewhat misleading. These artifacts could reflect an arithmetical or administrative

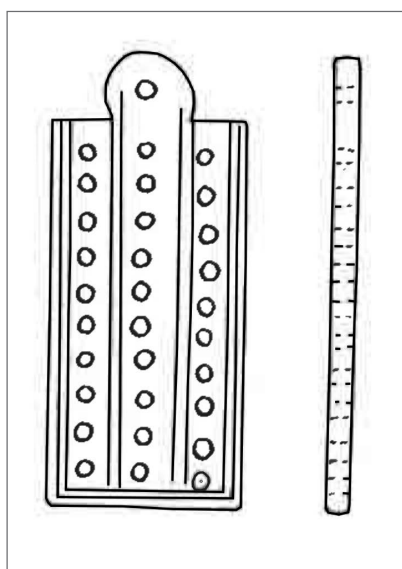


Fig. 1. A calendar plaque from Lachish (after Tufnell 1953: Pl. 56:23; image processing by Yuliya Gumenny, IAA; the original drawing was published without a scale).



Fig. 2. A calendar plaque from the City of David (photo V. Naikhin; courtesy of Ronny Reich).



Fig. 3. A calendar plaque from 'Aroer
(courtesy of David Ilan and the Nelson Glueck School of Biblical Archaeology).

function that is not yet fully understood. Notwithstanding, these possibilities are not mutually exclusive and merit further investigation.

6. The Use of Hieratic Numerals in the Arad Fortress

In addition to the structured calendrical practices described above, another compelling manifestation of Arad's numerical system appears in its use of hieratic numerals, a practice that further reveals the fortress's integration into broader scribal and bureaucratic traditions. These numerals originated in Egypt and reached neighboring regions as early as the Bronze Age, presumably through itinerant or relocated scribes (Goldwasser 1991; Vita 2012; Burke 2020). Scribes were firmly established in the Egyptian army (Malamat 2001; Imhausen 2003), and Na'aman (2020) has argued that Egyptian military centers in the Levant played a key role in the long-term process of hieratic application and adaptation (Wimmer 2008), which is likely to have continuously unfolded from the Late Bronze Age into the Iron Age (Wimmer 2024: 127).

7. Conclusions

The hieratic numerals in Arad's administrative records likely reflect a combination of inherited practices and adjustments to the local system's logistical needs. This interpretation supports our hypothesis that the six-day calendar at Arad was not only operational but was also integrated into a broader system of administrative planning.

Most ration distribution practices recorded in the Arad Ostraca correspond to timekeeping systems documented in the Bible and other Iron Age sources. However, some features of this corpus may reflect a calendar system that divided the month into five six-day periods. We suggest that, as in other military logistic systems, rations at Arad were distributed according to a planned schedule, and that goods, such as wine and bread, were issued based on this six-day cycle. The evidence suggests a rational and controlled system designed for logistical efficiency.

We propose that the scribes of Arad lived and worked in an environment for which numeracy was integral. This affected their vocabulary, syntax, and grammar, forming the language of a specific segment of the population—military logistics personnel—and distinguishing it from the wider society. As such, caution is warranted when drawing general conclusions about Biblical Hebrew from these documents. Only new archaeological evidence or the analysis of corpora equivalent in scale and quality to the Arad Ostraca will enable us to confirm, refine, or refute the arguments advanced in this article. Until such data emerge, the Arad texts remain a rare yet invaluable window into the evolution of this cognitive and administrative landscape.

8. Excursus: Early Appearances of Artificial Month Division in the Levant

From prehistoric times, natural phenomena such as the solar year and lunar month have shaped systems of time reckoning. However, developments in Bronze Age commerce—particularly the introduction of short-term loans—prompted the emergence of artificial temporal units, which are shorter than a month but longer than a day.

In Old Assyrian trading colonies, such as Kanesh (Kültepe, 21st–18th centuries BCE), loan contracts employ the term *hamuštum*, denoting such an intermediate time span. The term derives from the Semitic root for *five* (Michel 2010: 220). Von Soden (*Akkadisches Handwörterbuch* s.v. “AHw”) interpreted it as one-fifth of a month (i.e., six days); the *Chicago Assyrian Dictionary*

proposed that it denotes a group of five days, constituting a sixth of a month (CAD s.v. “hamuštum”), whereas other scholars have suggested it refers to a seven-day week (Bramanti 2015: 156 n. 5; Michel 2010: 220 n. 13). We do not draw a straight line between Bronze Age Anatolia and Iron Age Arad. Instead, we propose that in both contexts, the administrative efforts to manage labor, time, and resources are likely to have fostered the development or adoption of alternative calendrical frameworks.

The Arad Ostraca reveal a high degree of numeracy, which is comparable with patterns observed in Middle Kingdom Egypt, where military scribes were proficient in both literacy and numeracy (Imhausen 2003). However, numeracy in the southern Levant is comparatively poorly documented (Rollston 2006: 66–67; 2010: 116; Schniedewind 2014: 281–283).

References

- Aharoni, Y. 1981. *Arad Inscriptions*. Jerusalem: Israel Exploration Society.
- Ahituv, S., ed. 1987. *The Lachish Ostraca: A New Enlarged Impression*. Transcribed and interpreted by H. Torczyner. Jerusalem: Israel Exploration Society. (Hebrew).
- Ahituv, S. 2012. *HaKetav VeHmiktav*. Jerusalem: Mosad Bialik. (Hebrew).
- Akkadisches Handwörterbuch*. 1959. Compiled and edited by W. von Soden, unter benutzung des lexikalischen nachlasses von Bruno Meissner (1868–1947). Wiesbaden: Otto Harrassowitz.
- Baxter, W. T. 1989. Early Accounting: The Tally and Checkboard. *Accounting Historians Journal* 16/2: 43–83. <https://doi.org/10.2308/0148-4184.16.2.43>.
- Ben-Dov, J. A. 2021. A 360-Day Administrative Year in Ancient Israel: Judahite Portable Calendars and the Flood Account. *Harvard Theological Review* 114: 431–450.
- Bramanti, A. 2015. More on TMH 1, 354: An Old Assyrian Debt-Note in the Hilprecht Collection in Jena. *ISIMU: Revista sobre Oriente Próximo y Egipto en la Antigüedad* 11: 153–158.
- Burke, A. A. 2020. Left Behind: New Kingdom Specialists at the End of Egyptian Empire and the Emergence of Israelite Scribalism. Pp. 50–56 in “An Excellent Fortress for His Armies, a Refuge for the People”: *Egyptological, Archaeological, and Biblical Studies in Honor of James K. Hoffmeier*, ed. R. E. Averbeck, E. Richard, and K. Lawson Younger Jr. University Park, PA: Eisenbrauns.
- Canhão, T. F. 2013. A Timeless Legacy: The Calendars of Ancient Egypt. Pp. 283–301 in *Alexandria ad Aegyptum: The Legacy of Multiculturalism in Antiquity*, ed. R. Sousa, M. . C. Fialho, M. Haggag, and N. S. Rodrigues. Porto: Coimbra. https://doi.org/10.14195/978-989-26-0966-9_20.
- Chrisomalis, S. 2009. The Origins and Coevolution of Literacy and Numeracy. Pp. 59–74 in *The Cambridge Handbook of Literacy*, eds. D. R. Olson and N. Torrance. New York: Cambridge University Press.
- Dobbs-Allsopp, F. W., Roberts, J. J. M., Seow, C. L., and Whitaker, R. E. 2005. *Hebrew Inscriptions: Texts from the Biblical Period of the Monarchy with Concordance*. New Haven, CT: Yale University Press.
- Encyclopaedia Biblica*. 1958. Compiled by Y. S. Licht. Jerusalem: The Bialik Institute (Hebrew).

- Englund, R. K. 1988. Administrative Timekeeping in Ancient Mesopotamia. *Journal of the Economic and Social History of the Orient* 31: 121–185. <https://doi.org/10.2307/3632096>.
- Faigenbaum-Golovin, S., Shaus, A., Sober, B., Levin, D., Na'aman, N., Sass, B., Turkel, E., Piasetzky, E., and Finkelstein, I. 2016. Algorithmic Handwriting Analysis of Judah's Military Correspondence Sheds Light on Composition of Biblical Texts. *Proceedings of the National Academy of Sciences* 113: 4664–4669. <https://doi.org/10.1073/pnas.1522200113>.
- Faigenbaum-Golovin, S., Mendel-Geberovich, A., Shaus, A., Sober, B., Cordonsky, M., Levin, D., Moinester, M., Sass, B., Turkel, E., Piasetzky, E., and Finkelstein, I. 2017. Multispectral Imaging Reveals Biblical-Period Inscription Unnoticed for Half a Century. *PLoS ONE* 12: e0178400. <https://doi.org/10.1371/journal.pone.0178400>.
- Faigenbaum-Golovin, S., Shaus, A., Sober, B., Gerber, Y., Turkel, E., Piasetzky, E., and Finkelstein, I. 2021. Literacy in Judah and Israel: Algorithmic and Forensic Examination of the Arad and Samaria Ostraca. *Near Eastern Archaeology* 84: 148–158. <https://doi.org/10.1086/714070>.
- Garfinkel, Y., and Mendel-Geberovich, A. 2020. Hierarchy, Geography and Epigraphy: Administration in the Kingdom of Judah. *Oxford Journal of Archaeology* 39: 159–176.
- Gillings, R. J. 1972. *Mathematics in the Time of the Pharaohs*. Cambridge, AM: MIT Press.
- Goldwasser, O. 1991. An Egyptian Scribe from Lachish and the Hieratic Tradition of the Hebrew Kingdoms. *Tel Aviv* 18(2): 248–253.
- Grandell, A. 1977. The Reckoning Board and Tally Stick. *The Accounting Historians Journal* 4/1: 101–105.
- Grotlüschen, A., Desjardins, R. and Liu, H. 2020. Literacy and Numeracy: Global and Comparative Perspectives. *International Review of Education* 66: 127–137.
- Hanekon, D. 2004. *The Use of Donkeys for Transport as Pack Animals*. Pretoria: Agricultural Research Council.
- Herzog, Z. 1987. The Stratigraphy of Israelite Arad: A Rejoinder. *Bulletin of the American Schools of Oriental Research* 267: 77–79. <https://doi.org/10.2307/1356968>.
- Herzog, Z. 2002. The Fortress Mound at Tel Arad: An Interim Report. *Tel Aviv* 29: 83–109.
- Herzog, Z., Aharoni, M., Rainey, A. F., and Moshkovitz, S. 1984. The Israelite Fortress at Arad. *Bulletin of the American Schools of Oriental Research* 254: 1–34. <https://doi.org/10.2307/1357030>.
- Imhausen, A. 2003. Calculating the Daily Bread: Rations in Theory and Practice. *Historia Mathematica* 30: 3–16.
- Jones, P. A. 2001. The Multiple Uses of Donkeys in Generating Income for Rural and Urban People. Paper presented at the Annual Symposium of Interest Group on Developing Animal Agriculture, Nooitgedacht, October 2001.
- Kletter, R. 1998. *Economic keystones: The Weight System in the Kingdom of Judah*. Sheffield: Sheffield Academic Press.
- Kletter, R. 2009. Comment: Computational Intelligence, Lmlk Storage Jars and the Bath Unit in Iron Age Judah. *Journal of Archaeological Method and Theory* 16: 357–365.
- Kletter, R. 2014. Vessels and Measures: The Biblical Liquid Capacity System. *Israel Exploration Journal* 64: 22–37.
- Kletter, R. 2020. *Archaeology, Heritage and Ethics in the Western Wall Plaza, Jerusalem: Darkness at the End of the Tunnel*. London: Routledge.
- Lipschits, O., Koch, I., Shaus, A., and Guil, S. 2010. The Enigma of the Biblical Bath and the System of Liquid Volume Measurement during the First Temple Period. *Ugarit-Forschungen* 42: 453–478.

- Mandell, A. 2023. Word Craft in the Ancient Levant: Craft-Literacy as the Intersection of Specialized Knowledge. *Maarav* 27: 91–191.
- Malamat, A. 2001. Military Rationing in Papyrus Anastasi I and the Bible. Pp. 353–361 in *History of Biblical Israel: Major Problems and Minor Issues*. Leiden: Brill.
- Markowitz, W., Carswell Smart, J. J., and Toynbee, A. J. 2024. Lengths of Years and Months. *Encyclopedia Britannica*. <https://www.britannica.com/science/time/Lengths-of-years-and-months> (date of access 17 July 2025).
- Mazar, A. and Netzer, E. 1986. On the Israelite Fortress at Arad. *Bulletin of the American Schools of Oriental Research* 263: 87–91. <https://doi.org/10.2307/1356915>.
- Michel, C. 2010. The Day Unit within the Old Assyrian Calendar. Pp. 217–224 in *Studies Presented in Honour of Veysel Donbaz*, ed. Ş. Dönmez. Istanbul: Ege Publications.
- Na'aman, N. 2011. Textual and Historical Notes on the Elyashib Archive from Arad. *Tel Aviv* 38: 83–93. <https://doi.org/10.1179/033443511x12931017059503>.
- Na'aman, N. 2020. Egyptian Centres and the Distribution of the Alphabet in the Levant. *Tel Aviv* 47: 29–54. <https://doi.org/10.1080/03344355.2020.1707449>.
- Na'aman, N. 2022. Shortage of Quality Wine in an Arad Storehouse. *Maarav* 26: 27–38.
- Lemaire, A. 1977. *Inscriptiones Hebraiques*. Tome 1: *Les ostraca*. Paris: CERF.
- Pardee, D. 1978. Letters from Tel Arad. *Ugarit-Forschungen* 10: 289–336.
- Palchevska, O., Aleksandruk, I., Tyshchenko, O., Labenko, O., and Sydorenko, O. 2023. Military Slang: Origin, Structure and Semantics. *Amazonia Investiga* 69: 42–50. <https://doi.org/10.34069/AI/2023.69.09.3>.
- Porceddu, S., Jetsu, L., Markkanen, T., and Toivari-Viitala, J. 2008. Evidence of Periodicity in Ancient Egyptian Calendars of Lucky and Unlucky Days. *Cambridge Archaeological Journal* 18: 327–339. <https://doi.org/10.1017/S0959774308000395>.
- Renz, J. and Röllig, W. 1995. *Handbuch der althebräischen epigraphik, die althebräischen inschriften*. Darmstadt: Wissenschaftliche Buchgesellschaft.
- Robson, E. 2007. Literacy, Numeracy, and the State in Early Mesopotamia. Pp. 37–50 in *Literacy and the State in the Ancient Mediterranean*, eds. K. Lomas, R. Whitehouse, and J. Wilkins. London: Accordia Research Institute.
- Rollston, Ch. A. 2006. Scribal Education in Ancient Israel: The Old Hebrew Epigraphic Evidence. *Bulletin of the American Schools of Oriental Research* 344: 47–74.
- Rollston, C. A. 2010. *Writing and Literacy in the World of Ancient Israel: Epigraphic Evidence from the Iron Age*. Atlanta, GA: Society of Biblical Literature.
- Rosen, B. and Gorzalczy, A. 2024. Reinterpreting the Obscure Biblical Hebrew Lexeme צֶ'ע (Zō'e) in Arad Ostrakon 16. *Jerusalem Journal of Archaeology* 6: 32–45. <https://doi.org/10.52486/01.00006.2>.
- Royal Army Service Corps Training. 1933. Vol. III: *Supplies*. London: His Majesty's Stationery Office.
- Schniedewind, W. 2014. Understanding Scribal Education in Ancient Israel: A View from Kuntillet Ajrud. *Maarav* 21: 271–293.
- Torczyner, H. 1940. *The Lachish Ostraca*. Jerusalem: The Israel Exploration Society (Hebrew).
- Tufnell, O. 1953. *Lachish III (Tell ed-Duweir)*. London: Oxford University Press.
- Vainstub, D. 2024. The Management of Agricultural Taxes in the Valley of Arad as Reflected by Arad Ostraca. *Jerusalem Journal of Archaeology* 7: 80–99. <https://doi.org/10.52486/01.00007.5>.
- Vita, J.-P. 2012. On the Lexical Background of the Amarna Glosses. *Altorientalische Forschungen* 39: 278–286.

- Vymazalová, H. 2016. Ration System. Pp. 161 in *UCLA Encyclopedia of Egyptology*. Los Angeles, CA: University of California, Los Angeles. <https://escholarship.org/uc/item/8g74r617>.
- Wimmer, S. 2008. *Palästinisches Hieratisch: Die zahl- und sonderzeichen in der althebräischen schrift*. Wiesbaden: Harrassowitz.
- Wimmer, S. J. 2024. The “Scribal Turn” from Egyptian Hieratic to the Alphabet. *Jerusalem Journal of Archaeology* 7: 127–193. <https://doi.org/10.52486/01.00007.7>.